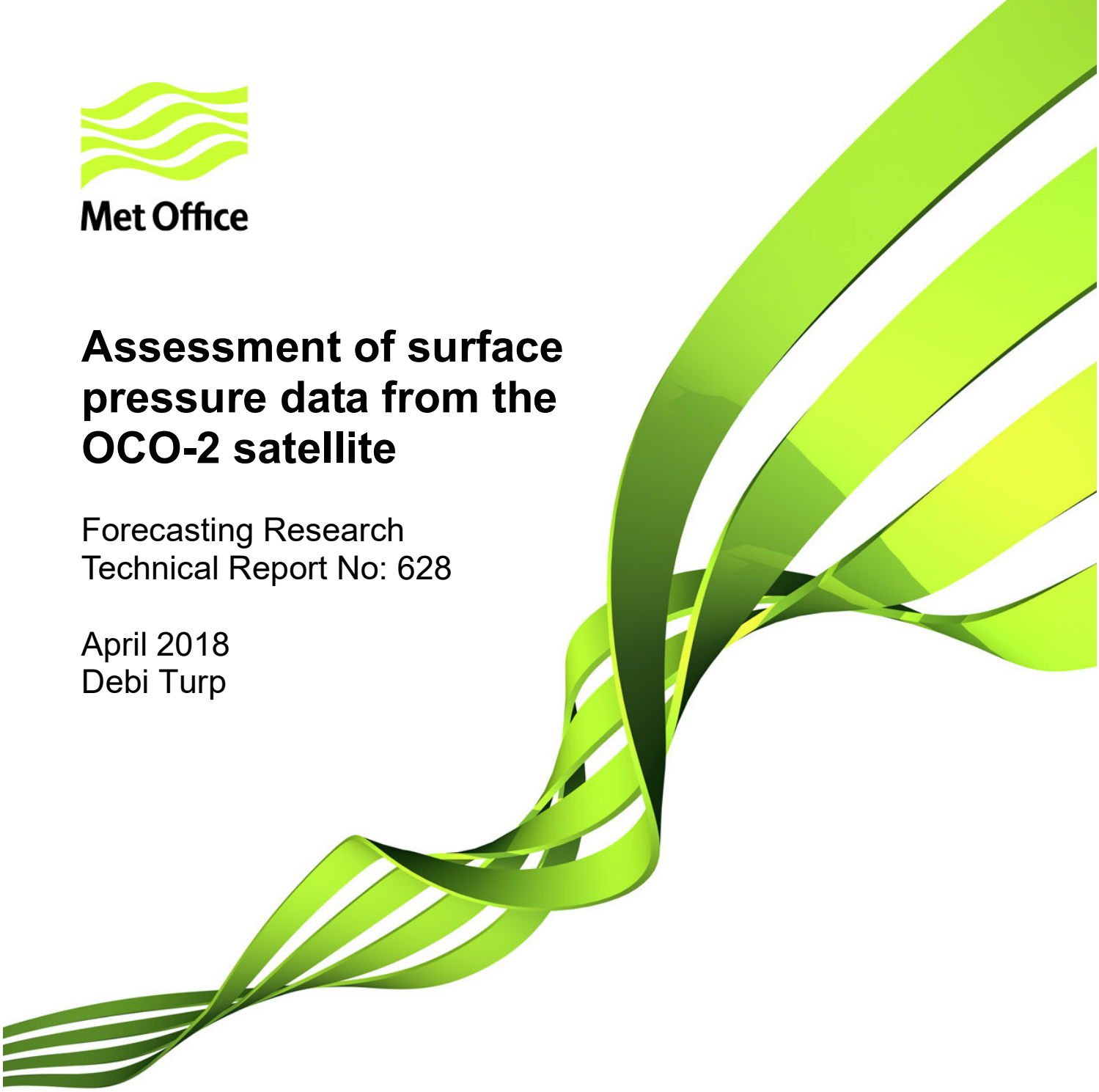

Assessment of surface pressure data from the OCO-2 satellite

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1 Introduction

The second satellite of the Orbiting Carbon Observatory programme (OCO-2) was launched in July 2014. The primary aim of the satellite was to collect atmospheric measurements of carbon dioxide (CO_2). Measurements of surface pressure were also produced as a side product from the processing of the CO_2 data. The aim of this study was to assess the suitability of this surface pressure data for assimilation into the Met Office's (global) numerical weather prediction (NWP) system. If suitable, this data source would boost the number of assimilated observations of surface pressure in data sparse areas such as over the world's oceans.

2 Data

The data used in this analysis were the surface pressure observations form the satellite and the background surface pressure data from the Met Office's operational (global) NWP system.

For this study, observations from the OCO-2 satellite were obtained from the Jet Propulsion Laboratory (JPL) via their website:
https://oco2.gesdisc.eosdis.nasa.gov/data/s4pa/OCO2_DATA/OCO2_L2_Lite_FP.8r/

The study used the latest version (8r) of the data from the "Lite" files, which were available from October 2017. These files were in NetCDF format and their names were in the form:
oco2_LtCO2_{YYMMDD}_B8199r_ {yymmddhhmmss}s.nc4
where YYMMDD was the acquisition date of the data and yymmddhhmmss was the production date and time of the data file.

These files included date, time, latitude, longitude and surface pressure observations, taken at a sampling rate of eight soundings every 0.333 seconds over a 0.8-degree wide band. The coverage of the data is illustrated in Figure 1.

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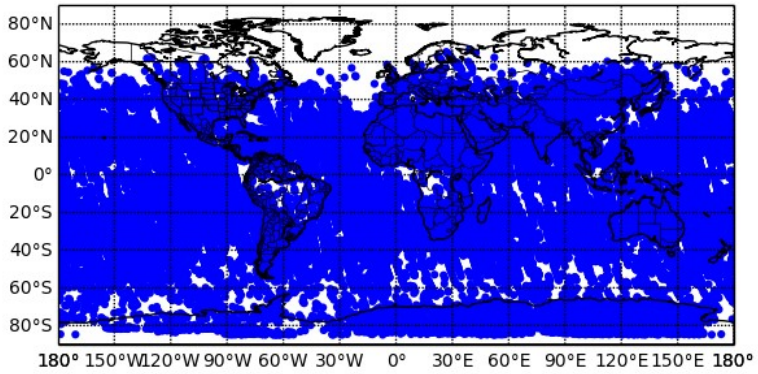

Figure 1. The location of every 100th observation from the OCO-2 satellite in January 2016.

These observations were compared with background surface pressure data from the Met Office's global Unified Model (UM). The model data used were the model rerun fields, which are short range (3 to 9 hours ahead) forecast fields used to re-run the model if required. The model data was linearly interpolated in space and time to obtain the model surface pressure value at the location of each satellite observation.

3 Data analysis

3.1 Methodology

Data for several different months were analysed to assess the seasonal variation in the bias. The months used were January, February, March, April, July and October 2016. In addition this study only used observations over the sea, to eliminate variations in surface pressure due to orography.

To compare the observations with the model data, the difference in the observational data was calculated using:

$$difference = observation\ value(O) - model\ backgound\ value(B)$$

These difference values were binned into 15º latitude x 15º longitude boxes. The mean and the standard deviation of the difference values were then calculated for each box. Figures 2, 3 and 4 show plots of the mean and standard deviation of the difference for the months studied.

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3.2 Results from data analysis

Figure 2 shows plots of the mean and standard deviation of the difference for four months in different seasons: January, April, July and October 2016.

There are large biases ranging from + 3hPa to –6 hPa in all the plots. There is a zone of positive bias across the tropics which shifts seasonally, moving northward in the Northern Hemisphere spring and southward in the Northern Hemisphere autumn.

The magnitude of the standard deviation of the difference was mostly between 2-5 hPa, with a minimum of <1 hPa and a maximum of >7 hPa in some areas. This also had a seasonal shift. In January, there was a zone of low standard deviation values (2-3 hPa) in the Southern Hemisphere and larger values (4-6 hPa) in the Northern hemisphere. In April, the zone of low standard deviation values shifted northwards to lie between 40ºN and 15ºS. In July the standard deviation was generally higher (3-5 hPa), with only a narrow zone of lower values around 20 deg N. In October the zone of lower values shifted southwards again and is more extensive.

Looking at the month-by-month variation in bias, this also varied with time of year, as illustrated in Figures 3 and 4. Comparing the adjacent Northern Hemisphere mid-winter (Southern Hemisphere mid-summer) months, January and February 2016, the variation in bias was generally about 0-2 hPa. However, comparing the adjacent months March and April 2016, occurring in the transition between winter and summer, the variation in bias was as large as 3-4 hPa (e.g. in the South Atlantic and South Pacific, around 60ºS and 40º S). Similarly, the monthly variation in the standard deviation of the bias was generally small (0-2 hPa) between January and February 2016, and larger in some areas (e.g. the South Pacific and South Atlantic around 60ºS and 40º S) between March and April 2016.

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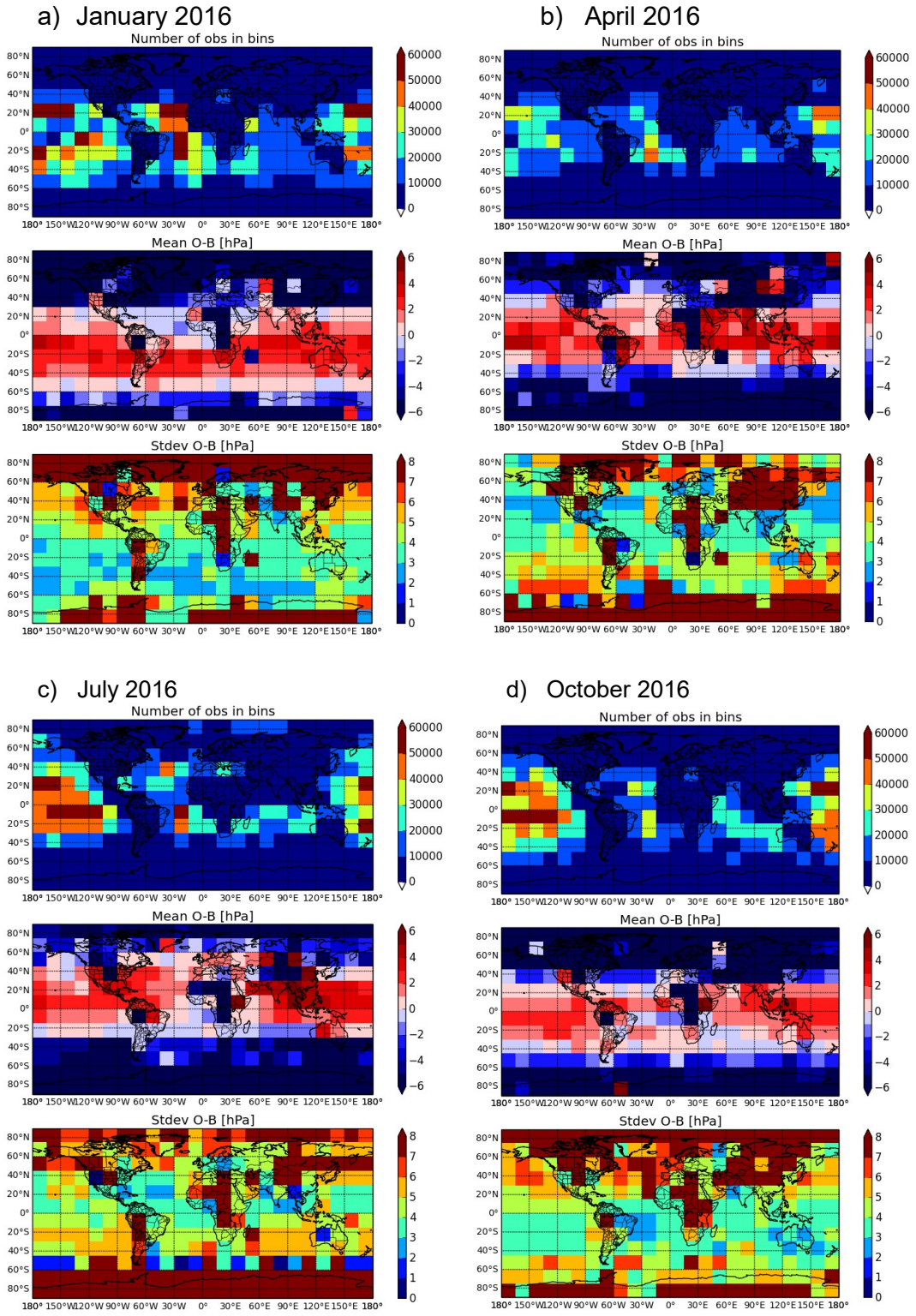

Figure 2. Plots showing the number of satellite observations, the mean bias (O-B) and standard deviation in bias (O-B) for months in different seasons: a) January, b) April, c) July and d) October 2016.

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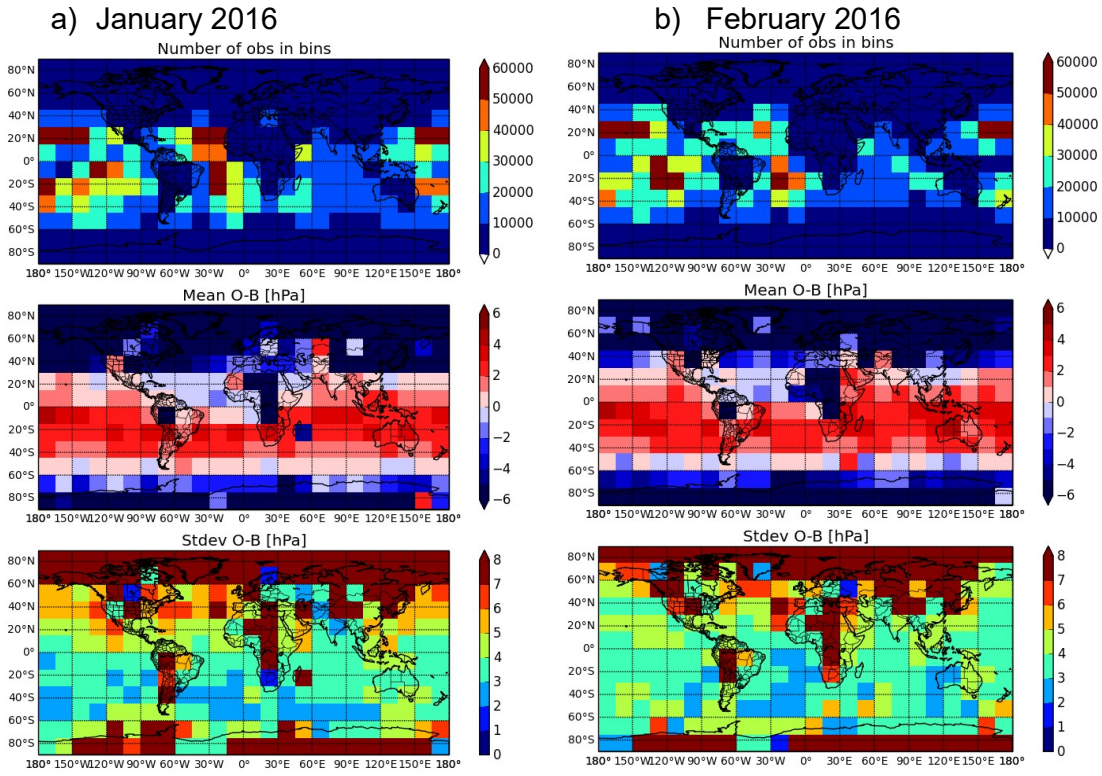

Figure 3. Plots showing the number of satellite observations, the mean bias (O-B) and standard deviation in bias (O-B) for the adjacent months a) January and b) February 2016.

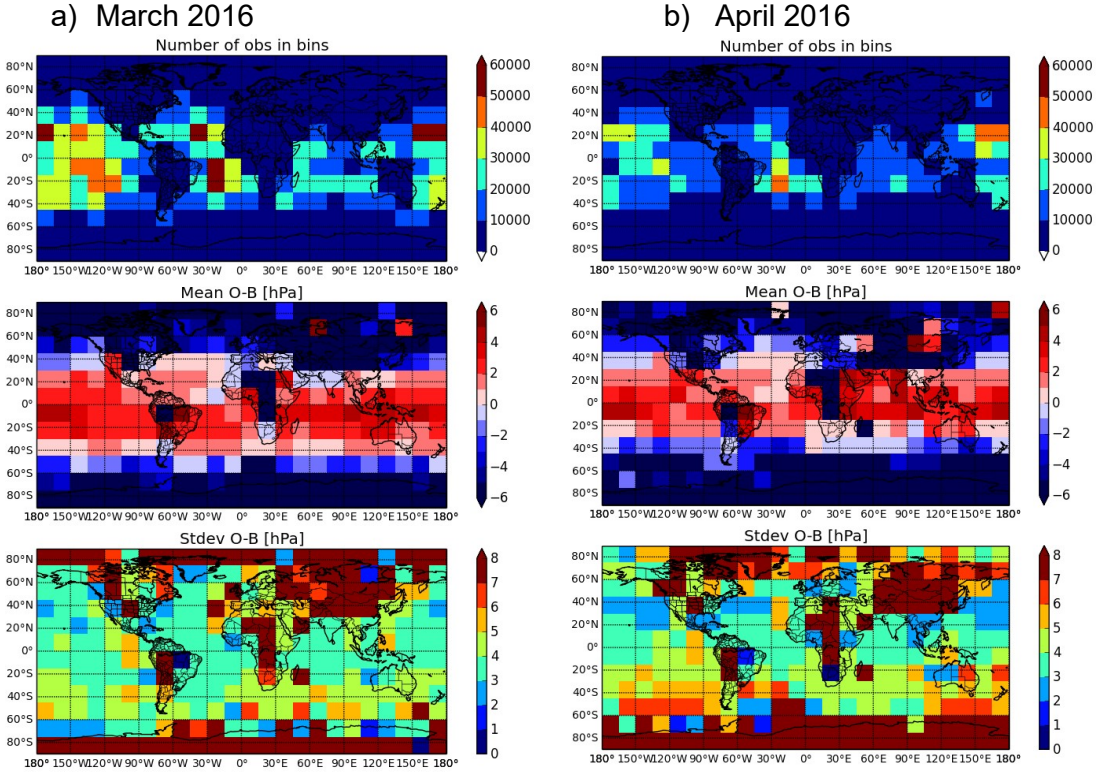

Figure 4. Plots showing the number of satellite observations, the mean bias (O-B) and standard deviation in bias (O-B) for the adjacent months a) March and b) April 2016.

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4 Summary

The bias pattern had a consistent structure, with a zone of positive bias at low latitudes flanked with zones of negative bias at higher latitudes. The bias pattern shifted with the seasons, with the positive bias zone moving northward in the Northern Hemisphere spring and southward in the Northern Hemisphere autumn. The month-to-month changes in bias were generally small.

The standard deviation of the bias also showed a consistent structure, with a broad zone of lower values which also shifted seasonally. However, the standard deviation generally ranged between 2-5 hPa, which is too large for the data to be considered suitable for assimilation into the Met Office's global numerical weather prediction model.

If the standard deviations could be reduced to <2 hPa (together with slowly varying biases), then these data would be strong candidates for use in NWP. Standard deviations of 2-3 hPa would make them marginally useful. Standard deviations above this would render the data of little value for NWP.

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